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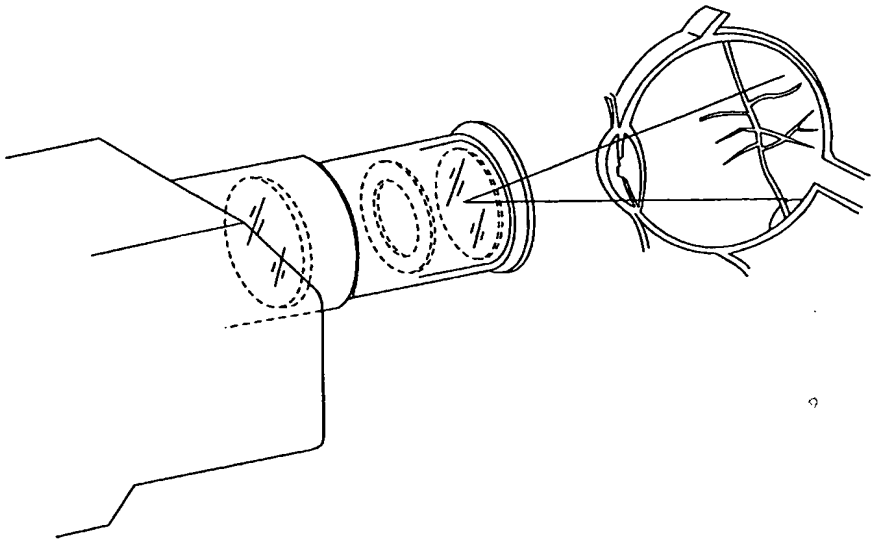

(57) Abstract

The present invention creates a permanent record of an animal through a series of steps including, preliminarily acquiring an image of the retinal vasculature of the animal of interest; digitizing that image if the image is not a digital image; analyzing the image to determine if the image is satisfactory for further analysis; storing the image; and analyzing the image for unique anatomical landmarks. The image and data gathered therefrom may be stored in a database for later retrieval and comparison against other images. The data gathered from the image may be compared against other stored data in the database to determine the identity of the animal. Preferably, the system would also include a global positioning system ("GPS") device which would simultaneously time and date stamp the acquired image as well as stamp the image with the location where the imaging took place by recording the latitude and longitude of that location.

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RETINAL VASCULATURE IMAGE ACQUISITION APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

1. Field Of The Invention

The present invention is directed generally to an apparatus and method for creating a record that can be used to identify an animal using biometric information gathered from the animal. More specifically, the present invention is directed to an apparatus and method for creating a record that can be used to identify an animal using biometric information gathered from the eye of the animal.

2. Description Of The Related Art

The issue of animal identification is as old as the domestication of animals by humans. Hot iron branding, for example, harks back to ancient Egypt. Until very recently, obvious and ancient methods of animal identification sufficed for social needs. Cattle in western United States range lands, for example, are still branded and companion animals, e.g., dogs and cats, are still tagged.

The advent of major new problems in various animal industries has accelerated the demand for new methods of identification. Most profound, perhaps, is the issue of food safety in the meat industry, particularly with respect to cattle. The emergence of dramatic new diseases carried in meat animals, most notably Bovine Spongiform Encephalopathy ("BSE" or "mad cow disease") and Johnne's disease, has generated a demand for individual animal identification that allows trace-back of each animal from current location (e.g., slaughterhouse) to birthplace. This concern carries over to other diseases such as brucellosis and tuberculoses, and also to toxicants and pollutants such as lead, PCBs, estrogen-mimicking compounds, and the like.

Apart from food safety concerns, conclusive and permanent identification of animals thus allowing for trace-back is important to animal related industries. Specifically, the cattle, pig, and sheep industries would benefit from the ability to trace these animals throughout their lives for numerous reasons, for example to determine proper title to the sold or purchased animal, to evaluate breeding operations, and to inventory herd animals, among others. These issues would be especially relevant to those involved in the raising and breeding of registered animals. Breeders of other animals, for example, cats and dogs would benefit from the ability to track animals, particularly registered animals, for title and genetic purposes. As aquaculture develops the need for conclusive and permanent fish identification would be important for the same

reasons as for the cattle industry. Veterinary medicine would benefit from the ability to positively identify the animal to be treated, thus assisting in rendering proper treatment to the animal. An additional benefit could be in facilitating the tracking of veterinary medical records. In the future, a conclusive and permanent means of identification could be important in order to differentiate genetically identical clones in all species.

In animal research, the animals (e.g., dogs, cats, mice, rats, pigs, primates, and the like) must be identified for record-keeping purposes. And, in the case of dogs and cats, proper identification is required to prove that the animal in the laboratory is not a kidnapped pet.

Accordingly, a conclusive means of identifying animals is needed. Numerous methods have been used in order to identify animals, all with various shortcomings. Hot iron branding has been used for centuries and is costly to the cattle industry in lost hide value. Moreover, it is painful to the animals. Freeze branding works only on dark hided animals. In addition, freeze branding is likewise painful to the animal and decreases the hide value. Tattooing is labor intensive, alterable, and difficult to read. Tattooing is likewise painful to the animal. Tags placed in the ears and other places on the animals are easily lost. Tags are easily removed and can be falsified.

Cutting the dewlaps and ear notching are both possibly alterable and painful to the animal. Using paint to mark an animal is non-permanent and possibly alterable. Microchips, whether implanted or in ear tags, are potentially alterable and expensive. Additionally, when implanted, microchips can migrate within the animal making them difficult to relocate and are not presently approved by the Food and Drug Administration ("FDA"). Moreover, at present, microchips have not been standardized, and thus, the proper reader may not be available to evaluate the information on the microchip implanted in the animal. Ear tags containing microchips suffer from the same drawbacks as regular ear tags in addition to the drawbacks relating to microchip usage. DNA testing is very expensive and requires a substantial amount of time to acquire the results. Furthermore, DNA testing would be unable to distinguish clones as they will have the same DNA. Considering the large number of animals that, for example, would be passed through a feedlot in a given period of time, DNA testing is not timely enough for trace-back purposes.

SUMMARY OF THE INVENTION

The present invention provides an apparatus and method which can be used to create a record which provides a conclusive and permanent means for identifying virtually any species of animal using biometric information gathered from the animal. The method of the present invention relies upon imaging the retinal vasculature of an individual animal to create the identifying record. Imaging the retinal vasculature provides a unique, unchanging, permanent, inexpensive, and unalterable method of identifying individual animals. Moreover, the method is equally effective on the eyes of living or recently dead animals.

The method of the present invention creates a permanent record of an animal through a series of steps including, preliminarily acquiring an image of the retinal vasculature of the animal of interest; digitizing that image if the image is not a digital image; analyzing the image to determine if the image is satisfactory for further analysis; storing the image; and analyzing the image for unique anatomical landmarks. The image and data gathered therefrom may be stored in a database for later retrieval and comparison against other images. The data gathered from the image may be compared against other stored data in the database to determine the identity of the animal, assuming that data has previously been gathered and stored on the same animal.

In an effort to increase the dependability of the data gathered and to reduce fraud and misrepresentation regarding the identity of an animal, when the digital image is confirmed as acceptable and acquired for further analysis, the latitude and longitude of the place where the image is created and the satellite set real time may be recorded along with the image.

The retinal imaging system of the present invention would likely include an imaging device, for example a digital camera and a conventional personal computer. Preferably, the system would also include a global positioning system ("GPS") device which would simultaneously time and date stamp the acquired image as well as stamp the image with the location where the imaging took place by recording the latitude and longitude of that location.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings in which:

Fig. 1 is an illustration of an image acquisition device projecting light through the pupil of an animal's eye onto its ocular fundus.

Fig. 2 is an illustration of a representative image of an animal's retinal vasculature showing the anatomical landmarks of interest.

Fig. 3 is an illustration of an acquired image of a cow's retinal vasculature.

Fig. 4 is an illustration of the image of Fig. 3 wherein the light-dark-light transitions have been detected.

Fig. 5 is an illustration of the image of Fig. 3 wherein the image has been rotated and normalized.

Fig. 6 is an illustration of the image of Fig. 3 wherein the unique anatomical landmarks of the particular animal's retinal vasculature have been detected so as to identify the subject animal.

Fig. 7 is a flowchart of a method of identifying and analyzing the retinal blood vessels within the ocular fundus.

DETAILED DESCRIPTION OF THE INVENTION

For the purposes of the present invention, "animal" means a human or animal having a holangiotic eye. A holangiotic eye is an eye having vasculature on the ocular fundus. Virtually all domestic animal species (with the exception of the horse) and many game animal species, including deer and elk, have holangiotic eyes.

Using the method of the present invention, a "fingerprint" is made of the subject animal's retinal vasculature and stored in a database. That "fingerprint" can then later be used to positively identify the same animal when "fingerprinted" again.

The validity of this method is based on the infinite variability that exists with respect to certain anatomical landmarks of the retinal vasculature. Use of digitized image information regarding the retinal vascular pattern for individual identification is applicable in those animals having holangiotic eyes. These animal species have a vascular pattern that consists of arterioles and venules originating and resuming to the optic nerve head or disk. Horses do not have holangiotic eyes and thus method of the present invention is presently not an effective means for identifying horses.

By targeting common structures such as the optic disk and dorsal retinal vascular branches, a consistent source of readily identifiable, yet contrasting structures are available for digital imaging and processing. Potential sensitivity and specificity of this system is very high since the precise vascular pattern geometric arrangement is unique between individuals. However, enough common features exist within species and breed groups that subcategorizing the data may be feasible to avoid the need to search an entire data set of all animals within the system.

Fig. 1 illustrates an image acquisition device 2 projecting light through the pupil 4 of the animal onto the animal's ocular fundus 6 so that an image may be acquired. As seen in Fig. 1, the ocular fundus 6 is the back of the inside of the eye opposite the pupil. Anatomically, the ocular fundus 6 consists of the retinal blood vessels 8, optical disk 10, tapetum lucidum, retinal pigment epithelium (retina), and choroid pigment. Fig. 2 indicates this anatomy as viewed via the image acquisition device. The tapetum lucidum is a reflective layer in the ocular fundus 6 and provides excellent contrast to the overlying retinal blood vessels 8. The tapetum is generally present above the optic disk 10 in most animals. Humans and pigs do not have a tapetum, but the ocular fundus in these animals provides a high contrast background against which the vascular bundle can be imaged and detected.

The method of the present invention focuses on identifying and analyzing the vascular bundle of the retinal blood vessels 8 extending across the ocular fundus 6 from the optical disk 10. These blood vessels and their branches, which can exist in infinite variations, offer a unique identifying attribute of the subject animal. Therefore, by accurately recording and analyzing the configuration of the blood vessels 8, the subject animal can be positively identified.

The method of the present invention is different from retinal scanning methods. Retinal scanning methods which are generally used to identify individuals for security purposes operate similar to bar code scanners. That is, they scan the inside of the eye, without capturing an image of it, looking for light-dark-light patterns similar to a bar code. Such methods are not as exacting as the method of the present invention and are thus not as accurate, either. Furthermore, the method of the present invention allows for the construction of libraries of images, while scanning methods do not have this capability. Besides identification purposes, these libraries may be able to be used for the evaluation of health changes in the animal that are manifested in retinal changes, for example diseases associated with Vitamin A and degenerative vascular

conditions. Certain physiological states, such as pregnancy, may also be detected in the images resulting from the method of the present invention.

The method of the present invention provides accurate results because the configuration of the retinal blood vessels 8 cannot be falsified or altered. Thus, the pattern of retinal blood vessels 8 offers an incredibly accurate, unalterable, and unchanging characteristic of the subject animal which can be relied on for identification purposes.

The apparatus of the present invention includes a means for capturing an image of the target retinal vasculature. For example, a digital camera, video camera, or camera using a charge coupled device ("CCD") would be acceptable. An exemplary device would be a SONY DSC-F1 with a 640x480 CCD imaging chip with infrared capability.

Affixed to the device used to acquire the image of the retinal vasculature would preferably be a lens that directs light (either infrared, low red, or visible) into the eye and allows a majority of the vascular bundle to be visualized. This type of lens system would be similar to a lens such as that used on a conventional ocular fundus camera. The lens could be a wide angle or "fish-eye" lens. Preferably, however, the lens would be a 100° to 120° angle, wide angle lens. The means by which light may be directed into the eye is not critical. Preferably, light would be directed into the eye by a ring light or other light source coupled to the lens.

The apparatus of the present invention would also preferably include a microprocessor and storage media. For the purposes of the present invention, "storage media" is defined as any acceptable means for electronically storing images and data including CD, disk, tape, "smart card", and the like. The microprocessor could be in the form of a stand alone personal computer ("PC"), or more preferably, would reside within the same housing as the device used to acquire an image of the retinal vasculature. The device used to acquire the image would preferably be a handheld, self-contained unit. In that case, the device would also include a means for inputting information and a means for viewing images and related information. Nonetheless, the device need not be handheld or self-contained to be acceptable for the purposes of the present invention. If a stand alone PC would be used, the device used to acquire the image of the target retinal vasculature could transfer data to the PC by any means, for example by infrared port, PC card, magnetic media (e.g., disk, CD, or tape), or cable.

Preferably, a GPS receiver would be used in conjunction with the device for acquiring an image of the animal's retinal vasculature. While the use of a GPS receiver in conjunction with

the device for acquiring an image of the animal's retinal vasculature is not necessary for the performance of the method of the present invention, the GPS receiver provides certain additional information which makes the record created of the animal's retinal vasculature more dependable and more difficult to falsify. The reason for this is that it would be almost impossible to falsify the identity of an animal if the initial and all later imaging records were accompanied by a location and time stamp as provided by a GPS receiver. The GPS receiver provides longitude and latitude data on the location where the record would be created accurate to within three meters. Presently, there is no known method to override or falsify this information because the GPS position data and other information would be encrypted. Preferably, all initial and all later identification records would be transmitted to a central control database where that information would be stored and be retrievable.

By accompanying an identification record with a GPS stamp including the location and time, the subject animal would essentially be assigned an address as is done with humans thus making it much more difficult for the identity of similar animals to be confused. Indeed, from the perspective of food safety, this accuracy is critical for identifying the source of a contaminant and other potentially infected animals and people who may have been exposed to the infected animal. For food safety purposes, it is important to be able to positively identify not only the animal, but also to be able to trace its previous locations. By including a GPS stamp with each identification record created, each previous location where an identification record was created on the animal would be identified in a manner that is virtually incontrovertible.

Assuming that all initial identification records and subsequent identification records are maintained in a central database, the records could be compared to determine the exact time and location of the last record taken on that individual. In essence, by combining a GPS receiver with the device for acquiring an image of the animal's retinal vasculature, the method of the present invention creates the equivalent of a social security identification system for animals. Because the information is so accurate, particularly with respect to the location of the animal at a precise time, cattle movements could be evaluated in near real time. Such information could have a stabilizing effect on commodity markets.

Furthermore, additional data could be added to the identification record by any known means, including audio recording, photographic record, digital encryption, and the like in the form of photographs of the animal and/or a feature or features of the animal; descriptions of the

subject animal; birth or death dates of the animal; genetic breeding data; cause of death; the medical/veterinary records of the animal including, data about past medical/veterinary treatment including programmed future required or necessary treatment; feed formulas; feedlot locations: border crossings; shipping data and locations; ownership transfers; purchaser required information, e.g., registration certificates; purchaser desired auction information; slaughter and packing company locations; distribution locations; and the like. With respect to identification of humans, any information deemed appropriate and allowed by law could be a part of the identification record.

Additionally, the images could be assigned unique bar-codes for each animal on which an identification record was generated. In the case of an animal sent to slaughter, such bar-code information could be used in a slaughterhouse or packing plant to identify parts of the animal as it proceeds through the meat packing process. Thus, any separate cut of meat, no matter where sold, could be accurately and easily traced back to the original animal based on the bar code.

Analysis of acquired images would occur either on board the device used to acquire the image or on the PC. Once a set of images has been accepted, analyzed, and the images and data stored electronically in storage media, the images and data may be transferred to a central location for further analysis and storage in a central database. The images and data may be communicated by any acceptable means of communication, for example over the Internet, by satellite communication, by facsimile, and the like. Images and data may be communicated to the central location allowing for near real time further processing. The transfer could occur via any acceptable means of real time, high-speed data transfer.

The method of the present invention includes the step of preliminarily acquiring an image of the retinal vasculature of the subject animal. One embodiment of the method is illustrated in the flowchart of Figure 7. For the purposes of this invention, virtually any animal with a holangiotic eye, including a human, would be an acceptable subject for the practice of the method. As stated above, the method of the present invention provides acceptable results on the eyes of both live and recently dead animals. The subject animal would be presented for evaluation. The evaluation may take place virtually anywhere because the device for acquiring an image of the animal's retinal vasculature is extremely portable and because of the evolution of rapid communication for the transfer of data. Nonetheless, the method of the present invention would be most likely carried out at a location where the animal would be most easily managed,

for example, at a medical clinic, at an on-farm working facility, at a veterinary clinic, at a feedlot, at a zoo, or similar facility.

The animal would be positioned relative to the device. The device would be activated so that light (e.g., infrared, low red, or visible) is projected into the eye of the animal through the pupil and onto the ocular fundus. An image of the animal's retinal vasculature would then be initially acquired by the image acquisition device. This is illustrated in Fig. 1. A representative acquired image is illustrated in Fig. 3.

Once the image has been initially acquired, the image, if not a digital image, would be digitized. Then, the image would be preliminarily analyzed to determine if that image would be satisfactory. The analysis performed on the image is to identify the vascular bundle of blood vessels 8, i.e., the major artery and vein that runs across the retina from the optic disk 10.

This analysis is accomplished using an object oriented algorithm which "slices" the image at an angle that is expected to be approximately perpendicular to the vascular bundle 8 when the device is held approximately level. The width of the slice (in pixels) and stride between slices may be varied as needed. The data in these slices would then be converted to a high contrast gray representation of the slice by averaging the red, green and blue octets of each pixel. Contrast may be adjusted by the user or may be set automatically. Each slice would then be tested for variation among the pixels. If sufficient variation exists, then the major transitions in the slice of light-dark-light pixels would then be detected using a moving average analysis. The number of pixels in the moving average may be varied as needed. The transition is detected by a threshold that is determined by the average pixel value in a larger moving average of pixels in the same slice. This allows for detection in variable contrast sections of the slice and between slices.

Referring to Fig. 4, when a light-dark-light transition is detected the location is marked by storing the coordinates of the center of the group of contiguous pixels in the current moving average in a linked list. Exemplary locations of the center coordinates of groups of contiguous pixels are marked on the image illustrated in Fig. 4 as 12.

When all slices of an image have been analyzed, the linked list of marked coordinates would be transferred to an algorithm that simultaneously normalizes the image and detects the coordinate of the axes produced by the vascular bundle 8 in the dimension the slices were taken. This analysis is accomplished by first performing a k-means cluster analysis in one dimension

using the same dimension in which the slices were taken. The maximum number of clusters allowed may be varied as needed. The image would then be rotated about the center of the image using standard image rotation methods in the radian scale and the cluster analysis repeated. A search for the best rotation would then be performed. The rotation of the image where the largest cluster has the most points from the linked list is the acceptable angle for normalization. Other known methods for determining the angle of normalization may be used if desired. At normalization, the coordinates in the plane in which the slices were taken that is represented by the largest cluster is also the location of the vascular bundle 8 in the perpendicular plane. This result is illustrated in Fig. 5.

If after the preliminary analysis, the initially acquired image meets certain minimal criteria the image may be accepted by the operator. The operator then signals acceptance of the normalized image by saving the image and preliminary analysis in an electronic storage medium. The minimal criteria for acceptance are based on the number of contiguous marks on the vascular bundle 8 (the size of the largest cluster). The minimum criteria include (l) a minimum number of points in the maximum sized cluster (which may be varied as needed) and (2) no other cluster has more than a maximum number of points (which also may be varied as needed). The operator would indicate acceptance of the image by saving the image to the storage medium on board the device or on the PC to which the image acquisition device is coupled.

Preferably, at the time the image is saved, the accepted image would be simultaneously stamped with an encrypted record of information taken from an attached GPS receiver. The resulting saved image, preliminary analysis data, and other relevant information comprise an identification record. Additional desired information could also be added, such as ownership, performance data, pedigrees, breed composition, and the like.

Once an identification record has been created, the image, preliminary analysis data, and information could be transferred to a stand alone PC, either at the site of the creation of the record or at a distant location, for additional analysis. Preferably, following the creation of the identification record, it would be transferred to a central location for additional analysis and storage in a database. The transfer of the information to the distant location could be done by any known means of communication, including transfer over phone lines, over the Internet, using satellite communication, by facsimile, and the like.

The additional analysis which the image undergoes is to determine the unique anatomical attributes of the retinal vasculature of the subject animal. In this step, at least two slices of the image are identified for further processing, one on each side of the axis of the vascular bundle 8 detected in the preliminary analysis of the image. The width, number, and exact location of the slices may be varied as needed. The analysis of the slices results in the creation of a unique digital "fingerprint" of the animal's retinal vasculature.

The slices are analyzed for light-dark-light transitions which correspond to the blood vessels branching from the vascular bundle 8. The coordinates of each of these transitions would then be detected. Referring to Fig. 6, the coordinates of each light-dark-light transition detected 14 makes a unique pattern with a sufficient number of combinations to assure that animals will be uniquely identified. At this point, a unique identification record has been created for the subject animal.

For the purposes of using a database of this information for identifying a specific animal, the data gathered from a newly generated identification record would be compared with data in the database.

CLAIMS

1. A method of creating an identification record for an individual animal, the method comprising:
   - acquiring an image of the ocular fundus of the animal,
   - locating anatomical features of the ocular fundus within the image, and
   - generating an identification record based on characteristics of the anatomical features.

2. The method of claim 1, wherein the step of acquiring an image comprises:
   - projecting light onto the ocular fundus of the animal, and
   - capturing an image of the ocular fundus with a camera.

3. The method of claim 2, wherein the step of projecting light comprises:
   - generating light with a wavelength in the infrared to visible range, and
   - directing the light onto the ocular fundus of the animal with a lens system.

4. The method of claim 3, wherein the step of capturing an image of the ocular fundus with a camera comprises capturing an image of the ocular fundus with a digital camera.

5. The method of claim 4, wherein the step of capturing an image of the ocular fundus with a digital camera further comprises storing the digital image.

6. The method of claim 5, wherein the step of storing the digital image comprises storing the image on storage media interfaced with the digital camera.

7. The method of claim 5, wherein the step of storing the digital image further comprises transmitting the image from the digital camera to a computer, and storing the image on storage media interfaced with the computer.

8. The method of claim 2, wherein the step of capturing an image of the ocular fundus with a camera further comprises digitizing the image.

9. The method of claim 8, wherein the step of capturing an image of the ocular fundus with a camera further comprises transmitting the digitized image to a computer, and storing the image on storage media interfaced with the computer.

10. The method of claim 1, wherein the step of locating anatomical features comprises identifying a particular structure within the ocular fundus, and the step of generating an identification record comprises characterizing sections of the image that are located in a predetermined configuration relative to the structure.

11. The method of claim 10, wherein the step of identifying a particular structure within the ocular fundus comprises identifying the vascular bundle.

12. The method of claim 10, wherein the step of identifying a particular structure within the ocular fundus comprises identifying the optic disk.

13. The method of claim 10, wherein the step of identifying a particular structure further comprises normalizing the image with respect to the structure.

14. The method of claim 13, wherein the step of normalizing the image with respect to the structure comprises rotating the image so that the structure lies in a predetermined orientation.

15. The method of claim 14 wherein the step of rotating the image comprises rotating the image so the axis of the vascular bundle lies in a substantially horizontal orientation.

16. The method of claim 10, wherein the step of identifying a particular structure further comprises determining whether the image is acceptable for further analysis.

17. The method of claim 10, wherein the step of characterizing sections of the image that are located in a predetermined configuration relative to the structure comprises:

- sampling sections of the image that lie in predetermined locations relative to the structure,
- detecting light-dark-light transitions within the sections,
- generating an identification record comprising the spatial coordinates of the light-dark-light transitions.

18. The method of claim 1, wherein the step of locating anatomical features of the ocular fundus within the image comprises:

- sampling a series of slices of the image,
- detecting light-dark-light transitions within the slices,
- storing the spatial coordinates of the transitions in a linked list,
- transferring the linked list to an algorithm that normalizes the image and detects a particular structure within the ocular fundus, and
- determining whether the image is acceptable for further analysis.

19. The method of claim 18, wherein the step of generating the identification record comprises:

- sampling slices of the image wherein the slices are in predetermined locations relative to the structure,
- detecting light-dark-light transitions within the slices,
- generating an identification record comprising the spatial coordinates of the light-dark-light transitions.

20. The method of claim 18, wherein the step of determining whether the image is acceptable for further analysis comprises comparing the number of contiguous transitions within the structure to a predetermined minimum threshold, whereby a structure containing more than the minimum number of contiguous transitions is acceptable for further analysis.

21. The method of claim 1, wherein the step of acquiring an image comprises capturing an image of the ocular fundus with a camera, whereby the ocular fundus is only illuminated by ambient light

22. A method of identifying an animal, the method comprising:

- gathering a first set of biometric information from an animal,
- generating an initial identification record comprising the biometric information and the identity of the animal,
- storing the initial identification record in a database, the database comprising a plurality of identification records,
- gathering a subsequent set of biometric information from the animal,
- generating a subsequent identification record comprising the subsequent set of biometric information, wherein the subsequent set of biometric information includes the same type of biometric information contained in the initial identification record, and
- determining the identity of the animal by
    - comparing the biometric information in the subsequent identification record to the biometric information in the identification records stored in the database in order to find a matching identification record, and
    - extracting the identity of the animal from the matching record.

23. The method of claim 22, wherein the biometric information comprises biometric information gathered from the animal's eye.

24. The method of claim 23, wherein the biometric information from the animal's eye comprises an image of the ocular fundus of the animal.

25. The method of claim 23, wherein the biometric information from the animal's eye comprises a retina scan.

26. The method of claim 22 wherein the steps of gathering a first set of biometric information and gathering a subsequent set of biometric information further comprise determining the time and location with a GPS receiver, and wherein the steps of generating an initial identification record and generating a subsequent identification record further comprise supplementing the identification record with the time and location recorded by the GPS receiver.

27. The method of claim 22, wherein the step of generating an initial identification record further comprises supplementing the record with additional data.

28. The method of claim 27, wherein the additional data includes audio data, visual data, a description of the animal, birth or death dates of the animal, genetic breeding data, veterinary records of the animal, feed formulas, feedlot locations, border crossings, shipping data, ownership transfers, or purchaser required information.

29. A method of improving the reliability of animal identification techniques, the method comprising:

- employing a GPS receiver to determine the time and location of the animal at the time a biometric measurement is collected,
- storing the GPS time and date information and the biometric measurement in an identification record,

whereby the addition of the GPS time and date information to the identification record makes the identification record more dependable and more difficult to falsify.

30. The method of claim 29, wherein the biometric measurement comprises a measurement involving the animal's eye.

31. The method of claim 29, wherein the biometric measurement comprises a retinal scan.

32. The method of claim 29, wherein the biometric measurement comprises an image of the ocular fundus of the animal.

33. The method of claim 29, wherein the biometric measurement comprises a measurement involving the animal's iris.

34. The method of claim 29, wherein the biometric measurement comprises DNA testing.

35. The method of claim 29, wherein the biometric measurement comprises an image of the animal.

36. The method of claim 29, wherein the information record comprises information from a microchip implanted in the animal.

37. An apparatus for creating an identification record for an individual animal, the apparatus comprising:

- an image acquisition device capable of capturing an image of the animal's ocular fundus, and
- an image analysis device capable of identifying anatomical features of the ocular fundus within the image.

38. The apparatus of claim 37, wherein the image acquisition device comprises a device for projecting light onto the ocular fundus of the animal, and a camera.

39. The apparatus of claim 38, wherein the device for projecting light onto the ocular fundus of the animal comprises a light source, and a lens system for directing the light onto the ocular fundus.

40. The apparatus of claim 39, wherein the light source produces light with a wavelength in the infrared to visible range.

41. The apparatus of claim 39, wherein the light source comprises a ring light.

42. The apparatus of claim 39, wherein the lens system comprises a wide-angle lens.

43. The apparatus of claim 38, wherein the device for projecting light and the camera are contained within a single housing.

44. The apparatus of claim 37, wherein the image acquisition device is capable of capturing an image of the animal's ocular fundus when the ocular fundus is only illuminated by ambient light.

45. The apparatus of claim 37, wherein the image analysis device comprises a microprocessor and storage media.

46. The apparatus of claim 45, wherein the microprocessor, storage media and the image acquisition device are contained in a single housing.

47. The apparatus of claim 45, wherein the microprocessor and storage media are components of a computer interfaced with the image acquisition device.

48. The apparatus of claim 37, wherein the image acquisition device further comprises a device capable of determining the location of the animal.

49. The apparatus of claim 45, wherein the device capable of determining the location of the animal comprises a GPS receiver.

50. A system for identifying an animal, the system comprising:

- a device for gathering biometric information from the animal,
- a device for storing an identification record, the identification record comprising the biometric information gathered from the animal and the identity of the animal, whereby a plurality of stored identification records form a database, and
- an analysis device capable of comparing biometric information gathered from an animal to biometric information in previously stored identification records in the database in order to find a matching identification record, and extracting the identity of the animal from the matching record.

51. The system of claim 50, wherein the device for gathering biometric information comprises:

- an image acquisition device capable of capturing an image of the animal's ocular fundus, and
- an image analysis device capable of identifying anatomical features of the ocular fundus within the image.

52. The system of claim 51, wherein the image analysis device comprises a first computer, and the analysis device capable of comparing an identification record generated from an animal to previously stored identification records comprises a second computer.

53. The system of claim 52, wherein data is transmitted from the first computer to the second computer by telephone, internet, satellite communication, or facsimile.

54. The system of claim 51, wherein a single computer comprises the image analysis device and the analysis device capable of comparing an identification record generated from an animal to previously stored identification records.

55. The system of claim 54, wherein the single computer and the image acquisition device reside within a single housing.

56. The system of claim 51, wherein the image is transferred from the image acquisition device to the image analysis device by an infrared port, PC card, magnetic media, or cable.

57. The system of claim 50, wherein the device for gathering biometric information comprises a retinal scanner.

58. The system of claim 50, wherein the device for gathering biometric information further comprises a GPS receiver.

59. The system of claim 50, wherein the device for storing an identification record comprises a device that stores information electronically.

60. The system of claim 59, wherein the device that stores information electronically comprises a compact disc, magnetic disc, optical disc, magnetic tape, or smart card.

61. The system of claim 50, wherein the device for gathering biometric information and the device for storing an identification record are enclosed in a single housing.

62. The system of claim 50, wherein the device for storing an identification record and the analysis device are enclosed in a single housing.

63. The system of claim 62, wherein the device for storing an identification record and the analysis device are components of a computer.

64. The system of claim 50, wherein the device for storing an identification record is a component of a computer, the device for gathering biometric information transmits the biometric information to the computer, and the biometric information is stored on storage media interfaced with the computer.

65. The system of claim 64, wherein the biometric information is transmitted to the computer by means of an infrared port, PC card, magnetic media, or cable.

66. An apparatus for creating an identification record for an individual animal, the apparatus comprising:

- means for illuminating the ocular fundus of the animal,
- means for capturing an image of the illuminated ocular fundus,
- means for storing the image, and
- means for characterizing the anatomical features of the ocular fundus.

67. A system for identifying an animal, the system comprising:

- means for gathering biometric information from the animal,

- means for storing an identification record, the identification record comprising the biometric data gathered from the animal and the identity of the animal, whereby a plurality of stored identification records form a database, and
- means of comparing an identification record generated from an animal to previously stored identification records in the database in order to find a matching identification record, and extracting the identity of the animal from the matching record.

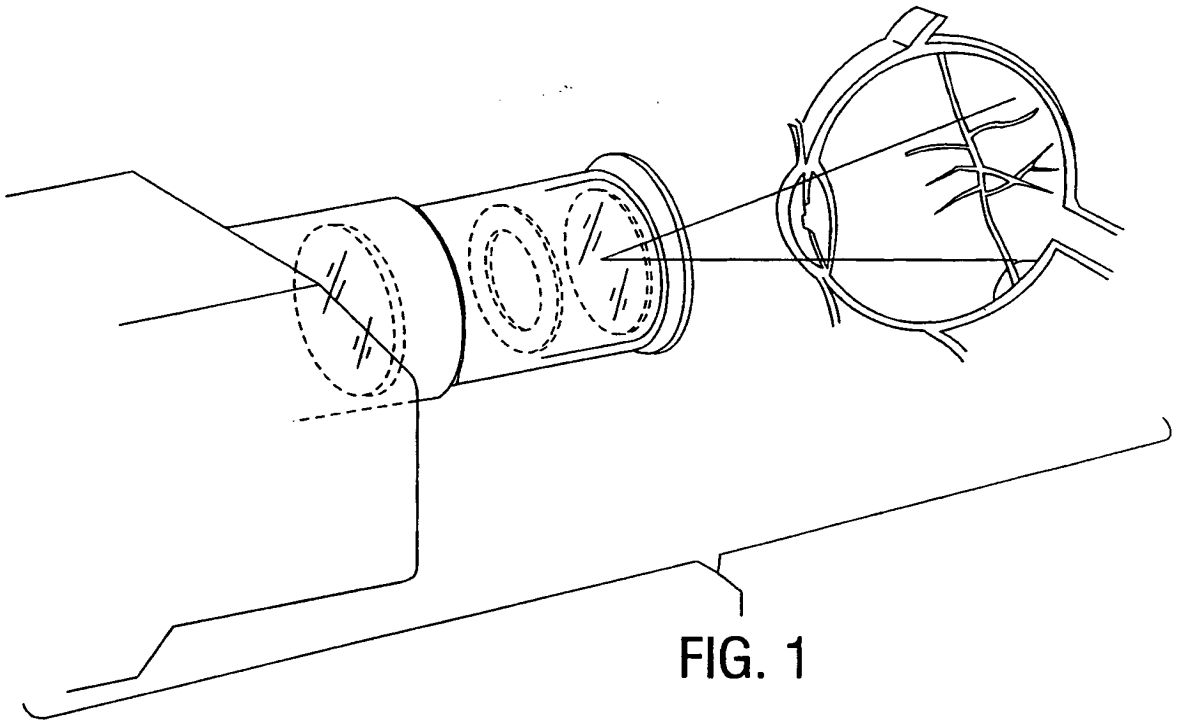

FIG. 1

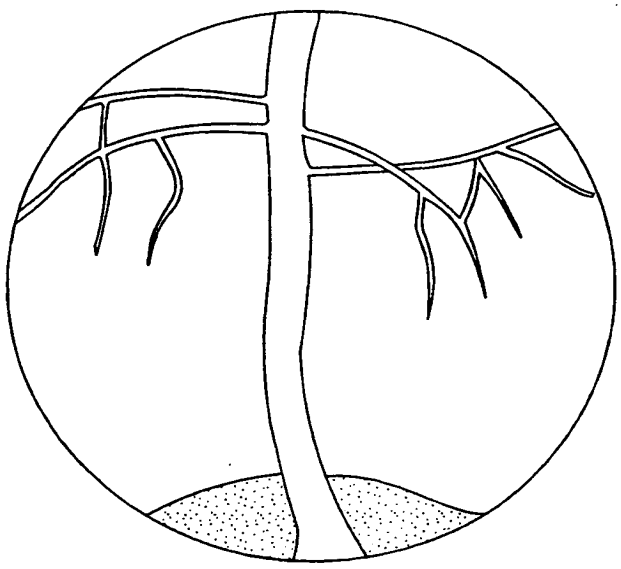

FIG. 2

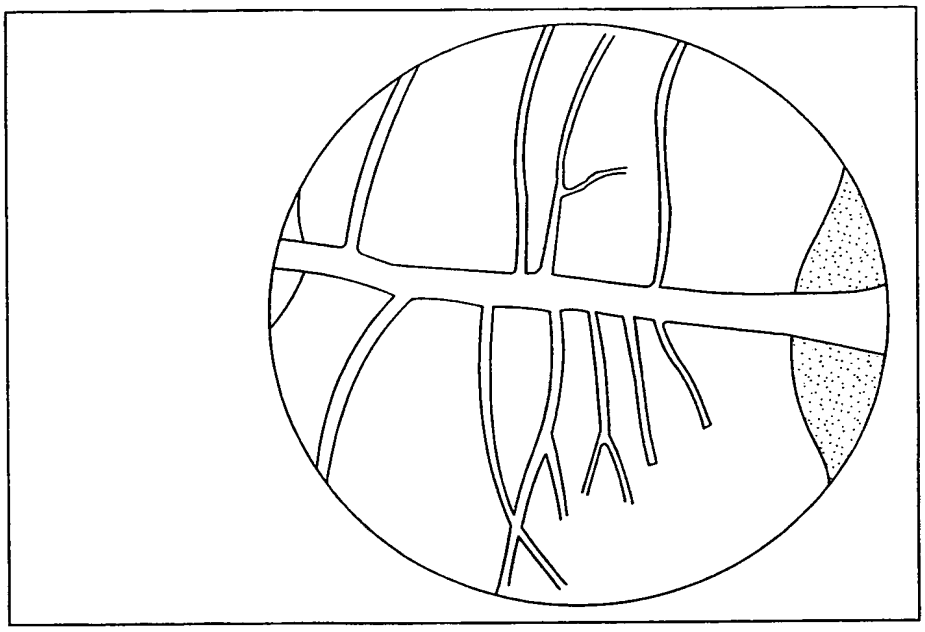

FIG. 3

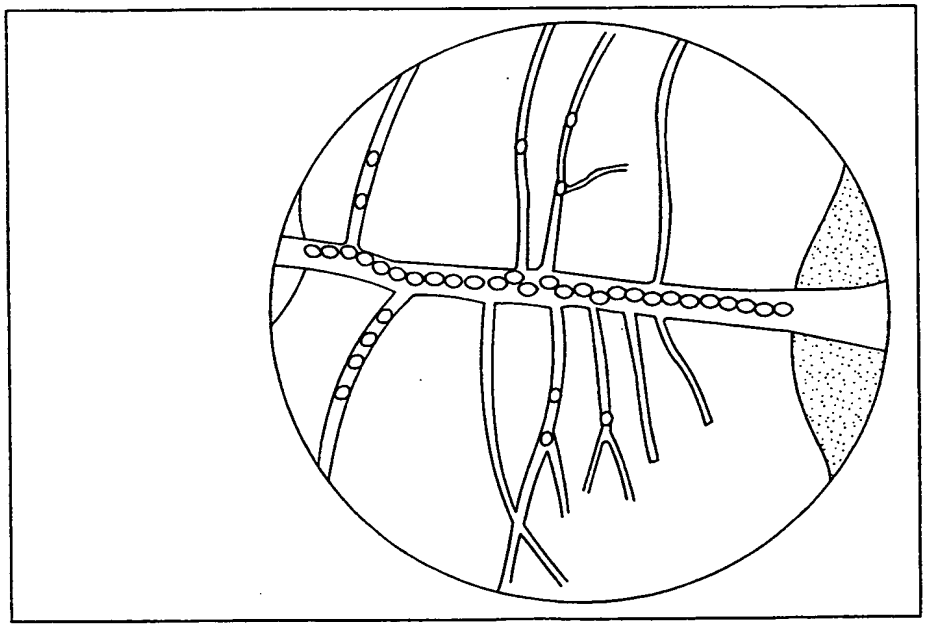

FIG. 4

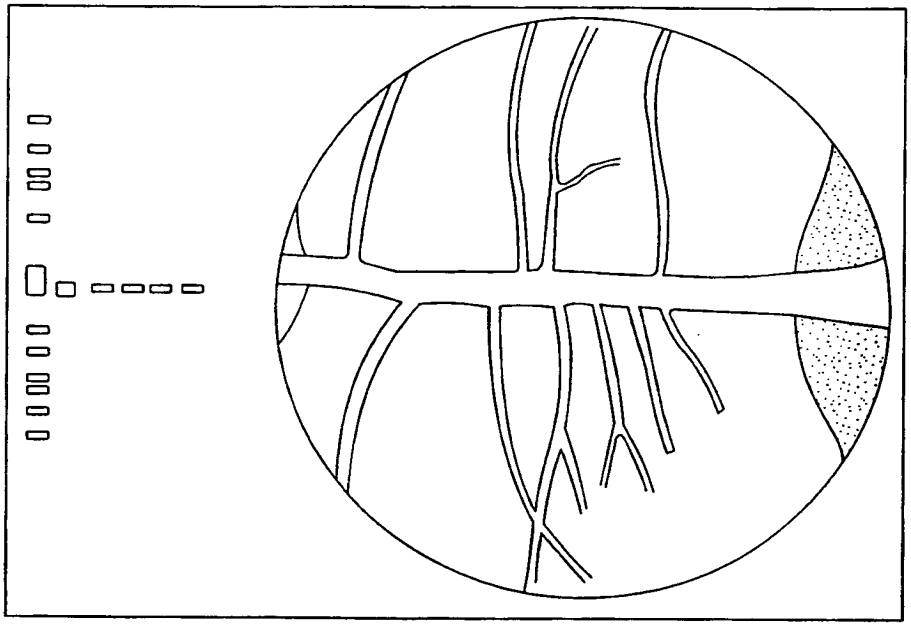

FIG. 5

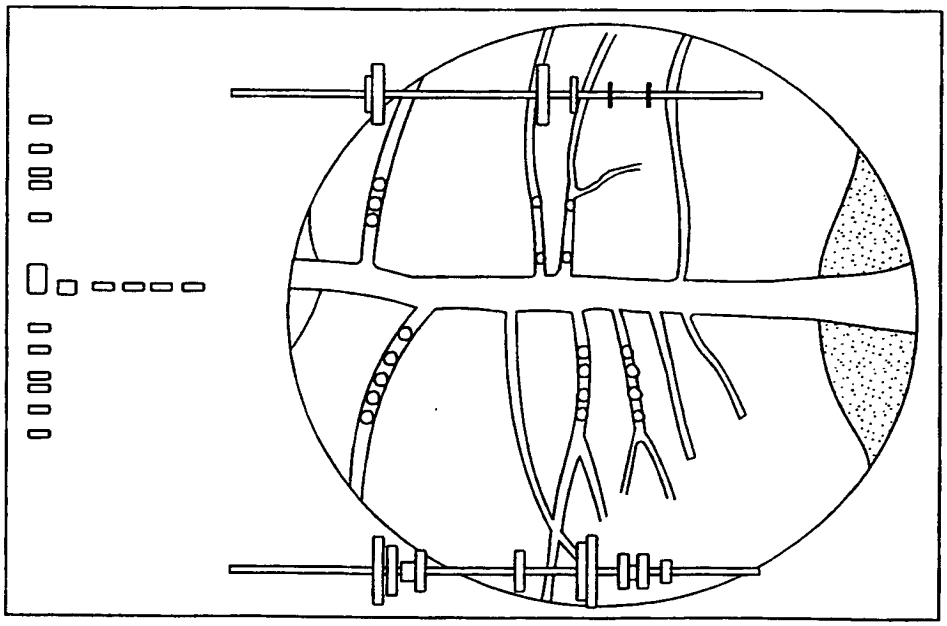

FIG. 6

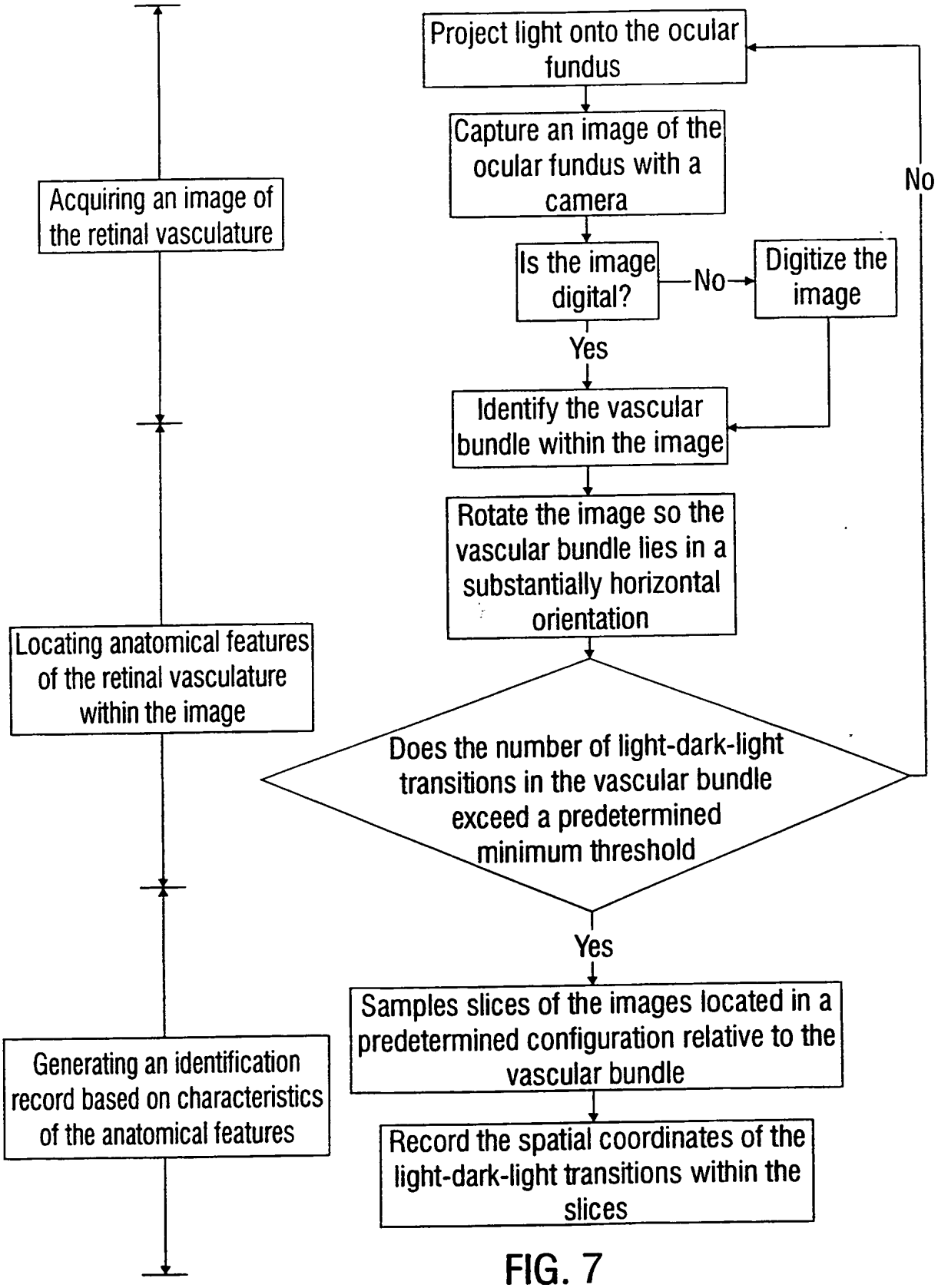

FIG. 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/[redacted]99/15337

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B3/14 A61B5/117 A01K11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B A01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 109 237 A (HILL ROBERT B) 22 August 1978 (1978-08-22)	22,23, 25,27, 50-57, 59-65,67
Y	column 2, line 59 -column 5, line 15; claims; figures	1-21,24, 37-47
X	EP 0 821 912 A (OKI ELECTRIC IND CO LTD) 4 February 1998 (1998-02-04) column 3, line 50 -column 5, line 51; claims; figures	22,23, 50, 59-65,67

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 October 1999	21/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Manschot, J

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Ir [redacted] onal Application No
PCT/U[redacted]/15337

C.(Continuation) DOCUMENTS CONSIDER[redacted]D BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 122 961 A (RODENSTOCK OPTIK G) 31 October 1984 (1984-10-31) page 8, line 18 -page 9, line 6 page 19, line 24 -page 22, line 4 page 34, line 1 -page 35, line 12; figures	1-3, 8-12, 17-21, 24,37-47
Y	WO 96 17545 A (JOSLIN DIABETES CENTER INC ;BURSELL SVEN ERIK (US); AIELLO LLOYD M) 13 June 1996 (1996-06-13) page 5, line 1 -page 7, line 25; claims; figures	1-7
Y	US 4 620 318 A (HILL ROBERT B) 28 October 1986 (1986-10-28) abstract; claims; figures	1,13-16
A	EP 0 758 752 A (MAASLAND NV) 19 February 1997 (1997-02-19) abstract; claims; figures	26-36, 48,49,58

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

[redacted] on patent family members

Ir[redacted]onal Application No
PCT/[redacted]99/15337

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4109237 A	22-08-1978	BR 7805230 A	14-08-1979
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EP 0758752 A	19-02-1997	NL 1000969 C	12-02-1997

INTERNATIONAL SEARCH REPORT

national application No.
PCT/[redacted]99/15337

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

SEE ADDITIONAL SHEET

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-21,37-49,66
Subject 1 relates to acquiring images of the ocular fundus for creating an identification record

2. Claims: 22-28,50-65,67
Subject 2 relates to identifying an animal by gathering and generating a record from biometric information

3. Claims: 29-36
Subject 3 relates to improving animal identification by employing a GPS receiver.